

Impact of China's currency valuation and labour cost on the US in a trade and exchange rate model*

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Abstract

Ricardian dynamic general equilibrium analyses show that under free trade arrangements a low income country with lower wage cost and large endowment of labour has comparative advantage in trade. Efficiency gains from this enhance economic growth and welfare of households simultaneously in both low income and advanced economies. Theoretical predictions are empirically validated here with structural VAR analysis based on quarterly data over the time period 1995:1 to 2009:1 on China's relative wage cost, interest rate differential, real effective exchange rate (REER), relative GDP and the US current account balance. It is shown how the relative prices of labour, capital and the currency affect the economic activity in China and current account balance in the US. With free capital inflows and outflows and restrictions on labour mobility, comparative advantage of China and the trade deficit of the US will both be minimised if China allows real appreciation of the Yuan and complete adjustment in prices. Higher production cost and prices in China will reduce welfare of Chinese households and the trade imbalance of the US.

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1 Introduction

International economic landscape has changed dramatically after the comparative advantage in producing goods and direction of trade have changed significantly in recent years. Interest has increased in understanding the new economic links between advanced economies and the emerging economies such as China that were able to grow at a reasonable space even during the financial crises and recessions of 2008/09. With a large current account surplus and apparently appreciating exchange rate, how do policies in China influence more advanced economies such as the US have become focus of attentions in the recent studies (see Corden (2009)). Large current account surplus of China impacts not only on the real effective exchange rate with its trading partners but also on the world real interest rate and the international relative prices of traded commodities and thereby on the current account deficit of the US. How do the relative prices set in this way affect the relative demand between China and the US and thereby create trade imbalances between the two countries is an issue this paper aims to explore using a dynamic trade model supported by empirical analysis.

The Chinese Yuan continues to remain under valued and a large body of the literature concentrates on studying the relation between exchange rate movements and the trade balance (see Bahmani-Oskooee and Ratha, 2010). According to WTO's current trade profile, US imports more than three times from China than it exports to China; nearly 17 percent of US total imports originate from China whereas only 5.6 percent of US exports go to China. Absolute price differentials and relative price volatility increase with exchange rate volatility (Imbs et al., 2010). Granville et al. (2011) explore price and exchange rate linkages between China and the G3 (US, Euro-area and Japan), showing that the price effect in China possibly due to lower cost is found to dominate the exchange rate effect on the US import prices. This suggests that we need to evaluate the relative impacts of exchange rate and production costs on the external balance in the US using a general equilibrium trade model with a monetary structure.

In order to address these underlying linkages of trade flows between two countries, we develop a neoclassical dynamic general equilibrium model based on the major developments in the literature¹.

¹Namely international finance model of Mundell (1957), benefits of free and liberal trade in Meade (1978), scale, product differentiation and pattern of trade in Krugman (1980), interaction among technology, geography and trade of Markusen and Swenson (1985), Eaton (1987) and Eaton and Kortum (1999), determinant of real exchange rate of Neary (1988), globalisation and location aspects in trade modeling in Krugman and Venables (1995) and Norman and Venables (1995), product differentiation and union negotiations of Naylor (2000), stochastic dynamic general equilibrium trade model of Melitz (2003), collapse of trade finance of Ahn et al (2011) and cross border market segmentation and markup theory of Gopinath *et al.* (2011).

We show that under free trade arrangements a low income country with lower wage cost and large endowment of labour has comparative advantage in trade, which improves welfare in both low income and advanced economies.

Theoretical predictions are empirically supported via a structural VAR analysis based on quarterly data over the time period 1995:1 to 2009:1 using China's relative wage cost, interest rate differential, real effective exchange rate (REER), relative GDP and the US current account balance. To understand the dynamics of trade and exchange rate between China and the US, a structural vector error correction model (VECM) is formulated as suggested in Fry and Pagan (2011) in order to derive long-run estimates, impulse responses and variance decompositions. It is shown how the relative prices of labour, capital and the currency affect the economic activity in China and current account balance in the US. With free capital flows and restrictions on labour mobility, comparative advantage of China and the trade deficit of the US will both be minimised if China allows real appreciation of the Yuan and complete adjustment in prices. Higher production cost and prices in China will reduce welfare of Chinese households and the trade imbalance of the US.

The rest of the paper is organized as follows. Section 2 presents the dynamic model of trade followed by analytical results in section 3, and data, estimation methodology and empirical results in section 4, variance decomposition analysis in section 5 and conclusions and the policy implications in section 6.

2 Two Country Dynamic Model of Trade and Exchange Rate

Traditional Ricardian, Heckscher-Ohlin, Stolper-Samuelson trade theories suggest that the pattern of trade is dominated by factor endowments, trade is beneficial for all trading partners and factor prices tend to equalise across the globe with free and liberal trade (Bhagwati (1964)). Generally economists since Ricardo have argued for removing tariff barriers to enhance welfare of all trading nations from specialisation according to the comparative advantage in production. As Johnson (1951-52) stated, *"countries with high tariffs may stand to gain, within limits, from a unilateral reduction in tariff barriers and maximum revenue will be always higher than the optimal tariff that raises welfare on trading nations."* Mundell (1957) explained implications on price equalisation process from trade on capital flows with or without free or restricted mobility of factors of production or trade

protections given the size and scale of industries of the trading nations. In a comparative static general equilibrium analysis Miller and Spencer (1977) had shown benefits to the UK of joining the European Union following Balassa's (1967) analysis on stages of integration in EU in the form of the custom union, a common market, an economic union and eventually a political union. Meade (1978) had felt a need for an elaborate dynamic model to capture the complex interactions among countries when he stated, *"perhaps a mysterious dynamic model operated inconspicuously in some back room by control experts for silent information of the authorities concerned might be useful; and in any case in the real world it would be desirable for the different authorities at least to communicate their plans to each other so that, by what one hopes would be a convergent process of mutual accommodation, some account could be taken of their interaction."*

Equipped with a sharper and more focused analytical structure Krugman (1980) pioneered incorporation of imperfect competition in trade models in which scale economies, increasing returns and larger domestic markets for exported products not only influence the patterns of intra-industry trade but also determines the numbers of firms in the industry. It makes Frankel and Musa (1981) believe that no macroeconomic policies can succeed unless it takes accounts of interlinkages created by patterns and structures of trade and relative prices of commodities. While the trade generated technical spillovers from the R & D investment of the profit maximising firms drives economic growth in Grossman and Helpman (1990), the globalisation and agglomerations may cause a relative decline in income of countries in peripheries despite a fall in the cost of transportation (Krugman and Venable (1995)). Trade in goods alone does not equalise factor prices as claimed in Stolper-Samuelson theorems (Norman and Venabale (1995)). Then with the endogenous growth models Ventura (1997) and Turnovsky (1999) illustrate how the patterns and benefits of trade relate to scale economies, innovations and productivity than traditional factor endowments. Union preferences matter both in one or two way trade with product differentiation (Naylor (2000)). Analysis of Ricardian absolute and comparative advantage and geographic barrier to trade requires solutions of structural equations derived from a general equilibrium model as in Eaton (1987) or Eaton and Kortum (2002) who apply their model to estimate gains from trade, technology diffusion and tariff reductions. In a two country stochastic general equilibrium model of trade and macroeconomic dynamics with monopolistic competition and heterogeneous firms Melitz (2003) illustrates how producer entry, product introduction and economic fluctuations are associated and connected to trade flows and changes in traded varieties across countries. With S-shaped correlations between various

leads and lags of GDP and trade flows he reproduces stylized facts on countercyclicality of trade patterns analogous to those in the international real business cycle models. Country size and trade policy matters in the division of gains between larger and smaller countries in the global trade (Bhattarai and Whalley (2008)).

Taking intuitive lessons from above theoretical developments regarding impacts of factor prices on real exchange rates and growth rate of trading nations we propose a dynamic two country open economy model of trade to ascertain factors that determine mutual gains from free trade and cause flows of capital when trade does not balance. Then we test the model with empirical evidences on relative growth rates, wages, the interest rate and the real exchange rates and trade balances of the US and China to explain recent developments and to speculate what might happen to them in the future. Each country consumes goods produced at home and produced in the partner country and uses labour along with capital in production. Domestic and foreign wage, interest rates and relative prices are determined by the optimality conditions when economic activities of two countries are connected through the real exchange rate. Those optimal conditions which are subject to shocks of technological progress, preferences and policy from time to time will cause a deviation from the optimal equilibrium as capital is mobile across countries but not the labour.

Our model consists of a home country i and a foreign country j . The utility function of a representative household in country i contains goods produced at home ($C_{i,t}$), imported from abroad ($M_{i,t}$) and the leisure ($l_{i,t}$). Government uses taxes on consumption ($tc_{i,t}$), imported goods ($tm_{i,t}$) and labour income ($tw_{i,t}$) to provide for public consumption ($G_{i,t}$). With the Cobb-Douglas utility function and the subjective discount factor ($0 < \theta_i < 1$), the intertemporal problem of the representative household in home country i can be stated as:

$$\max U_0^i = \sum_{t=0}^{\infty} \theta_i^t \left(C_{i,t}^{\alpha_i} M_{i,t}^{\beta_i} l_{i,t}^{\gamma_i} \right) \quad (1)$$

subject to its intertemporal budget constraint:

$$\begin{aligned} & \left[\sum_{t=0}^{\infty} P_{i,t} (1 + tc_i) C_{i,t} + P_{j,t} (1 + tm_i) M_{i,t} + w_{j,t} (1 - tw_i) l_{i,t} \right] \\ & \leq \left[\sum_{t=0}^{\infty} w_{i,t} (1 - tw_i) \bar{L}_{i,t} + r_{j,t} (1 - tk_i) K_{i,t} \right] \end{aligned} \quad (2)$$

where share parameters, each between zero and one ($0 < \alpha_i, \beta_i, \gamma_i < 1$), sum to one ($\alpha_i + \beta_i + \gamma_i = 1$). Shocks to the preferences in this model occur either with changes in the subjective discount factor θ_i or in share parameters α_i, β_i and γ_i . The representative households in the foreign country j solves similar intertemporal problem.

A representative firm in home country i maximises profit ($\Pi_{i,t}$) in a similar way supplying output ($Y_{i,t}$) with labour ($LS_{i,t}$) and capital inputs ($K_{i,t}$) as in Eaton (1985) and Grossman and Helpman (1990):

$$\max \Pi_{i,t} = P_{i,t}Y_{i,t} - r_{i,t}K_{i,t} - w_{i,t}LS_{i,t} \quad (3)$$

subject to the technology and accumulation constraints:

$$Y_{i,t} = A_{i,t}K_{i,t}^{\eta_t}L_{i,t}^{(1-\eta_t)} \quad (4)$$

$$I_{i,t} = K_{i,t} - (1 - \delta) K_{i,t-1} \quad (5)$$

Random productivity shocks $A_{i,t}$ with constant mean \bar{A}_i and variance σ_i^2 influence output of firms. Investment ($I_{i,t}$) net of depreciation ($\delta K_{i,t-1}$) contributes to the accumulation of capital stock.

Government receives revenue ($R_{i,t}$) from taxes on consumption and imports as well as in labour and capital income and spends on public services ($G_{i,t}$) as:

$$R_{i,t} = tc_i P_{i,t} C_{i,t} + tm_i P_{j,t} M_{i,t} + tw_i w_{j,t} LS_{i,t} + tk_i r_i K_{i,t} \leq G_{i,t} \quad (6)$$

Markets for goods clear but can be segmented across borders (Gopinath et al. (2011)):

$$Y_{i,t} = C_{i,t} + I_{i,t} + X_{i,t} - M_{i,t} + G_{i,t} \quad (7)$$

Labour market clears at national level as in Markusen and Svensson (1985):

$$\bar{L}_{i,t} = LS_{i,t} + l_{i,t} \quad (8)$$

The foreign country j has similar specification of technology and labour markets. There can be two different ways of trade balance. First one where trade is balanced period by period in the sense

that value of export and imports are the same for country i as:

$$P_{i,t}X_{i,t} = P_{j,t}M_{i,t} \quad (9)$$

Trade is financed by the flow of credits which is subject to trade-finance shocks as in Ahn et al. (2011):

$$(S_{i,t} - I_{i,t}) + (X_{i,t} - M_{i,t}) = 0 \quad (10)$$

Another way to make trade balanced intertemporally (in the present value terms) as:

$$\sum_{t=0}^{\infty} \theta^t (P_{i,t}X_{i,t} - P_{j,t}M_{i,t}) = \sum_{t=0}^{\infty} \theta^t (TB_{i,t}) = \sum_{t=0}^{\infty} \theta^t (\Delta F_{i,t}) = 0 \quad (11)$$

Imbalances result in the accumulation of foreign assets temporarily but should disappear in the long run though this may last far long in the future. A country with trade surplus ($TB_{i,t} > 0$) accumulates foreign assets (F_t) and one with deficit ($TB_{i,t} < 0$) decumulates it. The dynamics of foreign asset accumulation is by the real interest rate as:

$$F_{i,t+1} = F_{i,t} (1 + r_{i,t}) + \Delta F_{i,t} \quad (12)$$

Stocks of these assets increase options available to an economy in investment ($I_{i,t}$) or adoption of a new technology ($A_{i,t}$) which determine growth of output and welfare of households in it. Depletion of these assets persistently can influence on confidence of consumers and producers, lower growth rate and can cause financial and economic crisis.

Current price of commodity in country i is linked to the future price and the interest rate through an inter-temporal arbitrage condition as:

$$P_{i,t} = \frac{P_{i,t+1}}{1 + r_{i,t}} \quad (13)$$

Bilateral real exchange rate for country i is expressed in ratios of domestic and foreign prices for countries i and j respectively as:

$$E_{i,t} = \frac{P_{i,t}}{P_{j,t}} \quad (14)$$

A competitive equilibrium in this two country trade model is given by the sequence of prices $\{P_{i,t}, P_{j,t}\}$ interest rates, $\{r_{i,t}, r_{j,t}\}$ wage rates $\{w_{i,t}, w_{j,t}\}$, the real exchange rates, $\{E_{i,t}, E_{j,t}\}$ such that given public policies that include taxes in consumption $\{tc_{i,t}, tc_{j,t}\}$ labour income $\{tw_{i,t}, tw_{j,t}\}$ and capital income $\{tr_{i,t}, tr_{j,t}\}$ and imports tariffs $\{tm_{i,t}, tm_{j,t}\}$ the allocations of consumption, imports, leisure, $\{C_{i,t}, M_{j,t}, l_{i,t}, C_{j,t}, M_{i,t}, l_{j,t}\}$ that maximise the lifetime utility of households U_0^i and U_0^j in home and the foreign countries. The choices labour and capital inputs $\{LS_{i,t}, K_{j,t}, K_{i,t}, LS_{j,t}\}$ maximise profit of firms and the government expenditures $\{G_{i,t}, G_{j,t}\}$ are compatible with the government revenue, $\{R_{i,t}, R_{j,t}\}$ and exports $\{X_{i,t}, X_{j,t}\}$ are compatible with imports $\{M_{i,t}, M_{j,t}\}$ in both countries. Market mechanism influences allocations of resources in both countries through the real exchange rate that depend on relative prices.

The infinite horizon problem is reduced to finite horizon by fixing the terminal period T to the far distance in the future. Similarly the labour endowments $\{\bar{L}_{i,t}, \bar{L}_{j,t}\}$ grow exogenously. Policy shocks to these economies occur through tax and tariff instruments such as $\{tc_{i,t}, tc_{j,t}, tm_{i,t}, tm_{j,t}, tw_{i,t}, tw_{j,t}, tr_{i,t}, tr_{j,t}\}$ that are determined by the policy makers taking national and international circumstances. The model parameters $\alpha_i, \beta_i, \gamma_i$ and θ_i are estimated from the data.

3 Analytical Results of Optimisation

Since the infinite horizon problem is analytically intractable model is solved using the first order intertemporal optimisation conditions for any two time intervals as these optimality should hold for any other periods. First order conditions for households with respect to consumption, imports, leisure and shadow prices for t and $t + 1$ periods are:

$$C_{i,t} : \quad \alpha_i \theta^t \left(C_t^{\alpha_i - 1} M_t^{\beta_i} l_t^{\gamma_i} \right) = \lambda_t P_{i,t} (1 + tc_i) \quad (15)$$

$$C_{i,t+1} : \quad \alpha_i \theta^{t+1} \left(C_{t+1}^{\alpha_i - 1} M_{t+1}^{\beta_i} l_{t+1}^{\gamma_i} \right) = \lambda_{t+1} P_{i,t+1} (1 + tc_i) \quad (16)$$

$$M_{i,t} : \quad \beta_i \theta^t \left(C_t^{\alpha_i} M_t^{\beta_i - 1} l_t^{\gamma_i} \right) = \lambda_t P_{j,t} (1 + tm_i) \quad (17)$$

$$M_{i,t+1} : \quad \beta_i \theta^{t+1} \left(C_{t+1}^{\alpha_i} M_{t+1}^{\beta_i-1} l_{t+1}^{\gamma_i} \right) = \lambda_{t+1} P_{j,t+1} (1 + tm_i) \quad (18)$$

$$l_{i,t} : \quad \gamma_i \theta_i^t \left(C_t^{\alpha_i} M_t^{\beta_i} l_t^{\gamma_i-1} \right) = \lambda_t w_{i,t} (1 - tw_i) \quad (19)$$

$$l_{i,t+1} : \quad \gamma_i \theta_i^{t+1} \left(C_{t+1}^{\alpha_i} M_{t+1}^{\beta_i} l_{t+1}^{\gamma_i-1} \right) = \lambda_{t+1} w_{i,t+1} (1 - tw_i) \quad (20)$$

$$\begin{aligned} \lambda_{i,t} : \quad & P_{i,t} (1 + tc_i) C_{i,t} + P_{j,t} (1 + tm_i) M_{i,t} + w_{j,t} (1 - tw_i) l_{i,t} \\ & = w_{i,t} (1 - tw_i) \bar{L}_{i,t} + r_{j,t} (1 - tk_i) K_{i,t} \end{aligned} \quad (21)$$

$$\begin{aligned} \lambda_{i,t+1} : \quad & P_{i,t+1} (1 + tc_i) C_{i,t+1} + P_{j,t+1} (1 + tm_i) M_{i,t+1} + w_{j,t+1} (1 - tw_i) l_{i,t+1} \\ & = w_{i,t+1} (1 - tw_i) \bar{L}_{i,t+1} + r_{j,t+1} (1 - tk_i) K_{i,t+1} \end{aligned} \quad (22)$$

Above first order conditions result in the Euler equations as follows:

$$\frac{C_{i,t}}{C_{i,t+1}} : \quad \frac{1}{\theta} \left(\frac{C_{i,t}}{C_{i,t+1}} \right)^{(\alpha_i-1)} \left(\frac{M_{i,t}}{M_{i,t+1}} \right)^{\beta_i} \left(\frac{l_{i,t}}{l_{i,t+1}} \right)^{\gamma_i} = \frac{P_{i,t}}{P_{j,t}} \quad (23)$$

$$\frac{M_{i,t}}{M_{i,t+1}} : \quad \frac{1}{\theta_i} \left(\frac{C_{i,t}}{C_{i,t+1}} \right)^{\alpha_i} \left(\frac{M_{i,t}}{M_{i,t+1}} \right)^{(\beta_i-1)} \left(\frac{l_{i,t}}{l_{i,t+1}} \right)^{\gamma_i} = \frac{P_{j,t}}{P_{j,t}} \quad (24)$$

$$\frac{M_{i,t}}{M_{i,t+1}} : \quad \frac{1}{\theta_i} \left(\frac{C_{i,t}}{C_{i,t+1}} \right)^{\alpha_i} \left(\frac{M_{i,t}}{M_{i,t+1}} \right)^{(\beta_i-1)} \left(\frac{l_{i,t}}{l_{i,t+1}} \right)^{\gamma_i} = \frac{w_{j,t}}{w_{i,t+1}} \quad (25)$$

$$\frac{C_{i,t+1}}{M_{i,t+1}} : \quad \frac{\alpha_i}{\beta_i} \left(\frac{M_{i,t+1}}{C_{i,t+1}} \right) = \frac{P_{i,t+1} (1 + tc_i)}{P_{j,t+1} (1 + tm_i)} \quad (26)$$

$$\frac{l_{i,t+1}}{M_{i,t+1}} : \quad \frac{\alpha_i}{\gamma_i} \left(\frac{l_{i,t+1}}{C_{i,t+1}} \right) = \frac{P_{i,t+1} (1 + tc_i)}{w_{i,t+1} (1 - tw_i)} \quad (27)$$

$$\frac{M_{i,t+1}}{l_{i,t+1}} : \quad \frac{\beta_i}{\gamma_i} \left(\frac{l_{i,t+1}}{M_{i,t+1}} \right) = \frac{P_{j,t+1} (1 + tm_i)}{w_{i,t+1} (1 - tw_i)} \quad (28)$$

Similarly the first order conditions for firms are:

$$\Pi_{i,t} = P_{i,t} Y_{i,t} - r_{i,t} K_{i,t} - w_{i,t} L S_{i,t} \quad (29)$$

$$K_{i,t} : \quad \eta_{i,t} P_{i,t} K_{i,t}^{\eta_t - 1} L_{i,t}^{(1-\eta_t)} = r_{i,t} \text{ or } \frac{\eta_{i,t} P_{i,t} Y_{i,t}}{K_{i,t}} = r_{i,t} \quad (30)$$

$$K_{j,t} : \quad \eta_{j,t} P_{j,t} K_{j,t}^{\eta_t - 1} L_{j,t}^{(1-\eta_t)} = r_{j,t} \text{ or } \frac{\eta_{j,t} P_{j,t} Y_{j,t}}{K_{j,t}} = r_{j,t} \quad (31)$$

$$L_{i,t} : \quad (1 - \eta_{i,t}) P_{i,t} K_{i,t}^{\eta_t} L_{i,t}^{-\eta_t} = w_{i,t} \text{ or } \frac{(1 - \eta_{i,t}) P_{i,t} Y_{i,t}}{L_{i,t}} = w_{i,t} \quad (32)$$

$$L_{j,t} : \quad (1 - \eta_{j,t}) P_{j,t} K_{j,t}^{\eta_t} L_{j,t}^{-\eta_t} = w_{j,t} \text{ or } \frac{(1 - \eta_{j,t}) P_{j,t} Y_{j,t}}{L_{j,t}} = w_{j,t}$$

Initial capital stocks and the terminal investment conditions for country i and j are:

$$K_{i,0} \text{ and } K_{j,0} \quad (33)$$

$$I_{i,t} = (g_i + \delta_i) K_{i,T-1}; \quad I_{j,t} = (g_j + \delta_j) K_{j,T-1} \quad (34)$$

Whether the wage rates and the interest rates are same or differ from one country to another depend partly upon the marginal productivity and mobility of factors and partly on the tariff rates across countries as mentioned in the literature above. If labour and capital are perfectly mobile then ratios of marginal productivities across two countries in equilibrium are same as the ratios of rental rates and wage rates as:

$$\frac{\eta_{j,t} P_{j,t} Y_{j,t}}{\eta_{i,t} P_{i,t} Y_{i,t}} \frac{K_{i,t}}{K_{j,t}} = \frac{r_{j,t}}{r_{i,t}} \quad (35)$$

$$\frac{(1 - \eta_{j,t}) P_{j,t} Y_{j,t}}{(1 - \eta_{i,t}) P_{i,t} Y_{i,t}} \frac{L_{i,t}}{L_{j,t}} = \frac{w_{j,t}}{w_{i,t}} \quad (36)$$

These conditions give us the equilibrium real exchange rate in terms of relative prices of commodities between two countries, which further relate to marginal productivities of labour and capital, rental rates and ratio of imports to domestic consumption as follows:

$$E_{i,t} = \frac{P_{i,t}}{P_{j,t}} = \frac{\eta_{i,t} Y_{i,t}}{\eta_{j,t} Y_{j,t}} \frac{K_{j,t}}{K_{i,t}} \frac{r_{j,t}}{r_{i,t}} = \frac{(1 - \eta_{i,t}) Y_{i,t}}{(1 - \eta_{j,t}) Y_{j,t}} \frac{L_{j,t}}{L_{i,t}} \frac{w_{j,t}}{w_{i,t}} = \frac{\alpha_i M_{i,t}}{\beta_i C_{i,t}} \frac{(1 + tm_i)}{(1 + tc_i)} \quad (37)$$

These theoretical derivations, similar to those in Bhattarai (2011), show interdependence of the exchange rates, relative output, relative wage rate, relative interest rate, consumption taxes and tariff rates between two trading nations. The model solutions can differ remarkably when two countries differ in productivities of capital ($\eta_{i,t}$, $\eta_{j,t}$) or interest rates ($r_{i,t}$, $r_{j,t}$) or the wage rates ($w_{i,t}$, $w_{j,t}$) or in the stock of capital ($K_{i,t}$, $K_{j,t}$) or endowments of labour ($L_{i,t}$, $L_{j,t}$) or in tariffs and tax rates ($tm_{i,t}$, $tc_{j,t}$) or in the preferences and technologies ($\theta_i, \alpha_i, \beta_i$). Cooperation in policies of home and foreign countries can result in mutually beneficial inflows and outflows or the retaliation could result in the collapse of trade as seen in 2008-09 recession when international demand or supply shocks had reduced the global trade by up to 14 percent. How such structural features of the real exchange rates underpin the patterns of the nominal exchange rates is well explained in the studies of Mundell (1957), Meade (1978), Miller and Spencer (1977), Eaton (1987), Neary (1988), Taylor (1995), Eaton and Kortum (1999). In short, the long run equilibrium real exchange rate is a consequence of the balancing forces of the demand and supply for home and foreign products.

4 Empirical Analysis on Trade and Exchange rate

We examine time series data of the China and the US on wages, interest rates, exchange rates, GDP, current account balance and the US trade deficit to find empirical evidence on above analysis. A structural VAR model estimated in line of Sim (1980) and Bernanke (1986) with restrictions appropriate to theoretical derivations (see Fry and Pagan (2011) for upto date review on this). We limit our analysis to five variables that include relative wage between China and the US (w_{cu}), interest rate differential between China and the US (r_{cu}), Chinese real effective exchange rate (e), GDP of China relative to that of the US (ry_{cu}) and the current account balance (CA_u) determining the ordering of these variables in the SVAR following logics explained in Rafiq and Mallick (2008).

In a nutshell we try to show how the relative prices of labour, capital and the currency affect the economic activities in China and trade balance in the US. The raw time series of these data are presented in Figure 1. When the Chinese economy has been growing rapidly, the exchange rate being fixed leads us to use China's real exchange rate ($e_{c,t}$) rather than the nominal exchange rate. By doing so, we are also capturing the relative price effect. China's unit labour cost (ULC) is measured as total wage bill over real output (nominal output divided by CPI (1985=100)). Then relative wage ($w_{cu,t}$) is calculated by dividing ULC-China over ULC-US. Relative GDP ($ry_{cu,t}$) on the other hand has been defined as Chinese GDP in dollar terms over US GDP. We calculate interest rate differential ($r_{cu,t}$) as the difference between Chinese average inter-bank rate and US 3-month Tbill rate. Current account balance ($CA_{u,t}$) for the US is used as the percentage of US nominal GDP. With these five variables, we formulate a first-order structural VAR of the following form:

$$\begin{bmatrix} b_{11} & b_{12} & b_{13} & b_{14} & b_{15} \\ b_{21} & b_{22} & b_{23} & b_{24} & b_{25} \\ b_{31} & b_{32} & b_{33} & b_{34} & b_{35} \\ b_{41} & b_{42} & b_{43} & b_{44} & b_{45} \\ b_{51} & b_{52} & b_{53} & b_{54} & b_{55} \end{bmatrix} \begin{bmatrix} w_{cu,t} \\ r_{cu,t} \\ e_{c,t} \\ ry_{cu,t} \\ CA_{u,t} \end{bmatrix} = \begin{bmatrix} b_{10} \\ b_{20} \\ b_{30} \\ b_{40} \\ b_{50} \end{bmatrix} + \begin{bmatrix} \gamma_{11} & \gamma_{12} & \gamma_{13} & \gamma_{14} & \gamma_{15} \\ \gamma_{21} & \gamma_{22} & \gamma_{23} & \gamma_{24} & \gamma_{25} \\ \gamma_{31} & \gamma_{32} & \gamma_{33} & \gamma_{34} & \gamma_{35} \\ \gamma_{41} & \gamma_{42} & \gamma_{43} & \gamma_{44} & \gamma_{45} \\ \gamma_{51} & \gamma_{52} & \gamma_{53} & \gamma_{54} & \gamma_{55} \end{bmatrix} \begin{bmatrix} w_{cu,t-1} \\ r_{cu,t-1} \\ e_{c,t-1} \\ ry_{cu,t-1} \\ CA_{u,t-1} \end{bmatrix} + \begin{bmatrix} \varepsilon_{wt} \\ \varepsilon_{rt} \\ \varepsilon_{et} \\ \varepsilon_{ryt} \\ \varepsilon_{cat} \end{bmatrix} \quad (38)$$

where matrix notations can be employed for more compact representation.

$$X_t = \begin{bmatrix} w_{cu,t} \\ r_{cu,t} \\ e_{c,t} \\ ry_{cu,t} \\ CA_{u,t} \end{bmatrix} ; X_{t-1} = \begin{bmatrix} w_{cu,t-1} \\ r_{cu,t-1} \\ e_{c,t-1} \\ ry_{cu,t-1} \\ CA_{u,t-1} \end{bmatrix} ; \varepsilon_t = \begin{bmatrix} \varepsilon_{wt} \\ \varepsilon_{rt} \\ \varepsilon_{et} \\ \varepsilon_{ryt} \\ \varepsilon_{cat} \end{bmatrix} \quad (39)$$

Thus the path of X_{it} is affected by both contemporaneous and lagged effects of X_{jt} as measured by Γ_0 and Γ_1 and its own past values. Consider

$$X_t = B^{-1}\Gamma_0 + B^{-1}\Gamma_1 X_{t-1} + B^{-1}\varepsilon_t \quad (40)$$

$$B^{-1} = \begin{bmatrix} b_{11} & b_{12} & b_{13} & b_{14} & b_{15} \\ b_{21} & b_{22} & b_{23} & b_{24} & b_{25} \\ b_{31} & b_{32} & b_{33} & b_{34} & b_{35} \\ b_{41} & b_{42} & b_{43} & b_{44} & b_{45} \\ b_{51} & b_{52} & b_{53} & b_{54} & b_{55} \end{bmatrix}^{-1} \quad \Gamma_0 = \begin{bmatrix} b_{10} \\ b_{20} \\ b_{30} \\ b_{40} \\ b_{50} \end{bmatrix}; \quad \Gamma_1 = \begin{bmatrix} \gamma_{11} & \gamma_{12} & \gamma_{13} & \gamma_{14} & \gamma_{15} \\ \gamma_{21} & \gamma_{22} & \gamma_{23} & \gamma_{24} & \gamma_{25} \\ \gamma_{31} & \gamma_{32} & \gamma_{33} & \gamma_{34} & \gamma_{35} \\ \gamma_{41} & \gamma_{42} & \gamma_{43} & \gamma_{44} & \gamma_{45} \\ \gamma_{51} & \gamma_{52} & \gamma_{53} & \gamma_{54} & \gamma_{55} \end{bmatrix}$$

The reduced form of this VAR system is then given by:

$$X_t = A_0 + A_1 X_{t-1} + e_t \quad (41)$$

where $A_0 = B^{-1}\Gamma_0$, $A_1 = B^{-1}\Gamma_1$, $e_t = B^{-1}\varepsilon_t$

Reduced form is estimated with the available data; then structural shocks are retrieved using $e_t = B^{-1}\varepsilon_t$. This requires estimation of the variance covariance matrix of the error term:

$$\Sigma = \begin{bmatrix} \sigma_{11} & \sigma_{12} & \sigma_{13} & \sigma_{14} & \sigma_{15} \\ \sigma_{21} & \sigma_{22} & \sigma_{23} & \sigma_{24} & \sigma_{25} \\ \sigma_{31} & \sigma_{32} & \sigma_{33} & \sigma_{34} & \sigma_{35} \\ \sigma_{41} & \sigma_{42} & \sigma_{43} & \sigma_{44} & \sigma_{45} \\ \sigma_{51} & \sigma_{52} & \sigma_{53} & \sigma_{54} & \sigma_{55} \end{bmatrix} \quad (42)$$

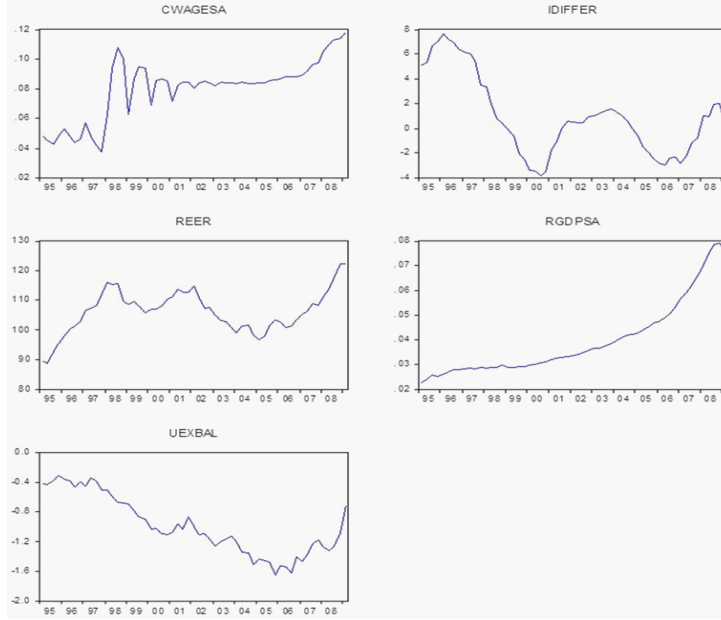
where $\sigma_{ij} = \frac{1}{T} \sum_{t=1}^T e_{ij} e'_{ij}$.

VAR is a-theoretic. In order to understand the long-run dynamics, we perform impulse response shock analysis, as the results from impulse responses are more informative than the estimated VAR regression coefficients (see Stock and Watson, 2001). It is customary to impose restrictions on coefficients based on prior economic theory. These restrictions can be on parameters, variance covariance matrices or symmetry.

$$\begin{bmatrix} a_{11} & 0 & 0 & 0 & 0 \\ a_{21} & a_{22} & 0 & 0 & 0 \\ a_{31} & a_{32} & a_{33} & 0 & 0 \\ a_{41} & a_{42} & a_{43} & a_{44} & 0 \\ a_{51} & a_{52} & a_{53} & a_{54} & a_{55} \end{bmatrix} \begin{bmatrix} w_{cu,t} \\ r_{cu,t} \\ e_{c,t} \\ ry_{cu,t} \\ CA_{u,t} \end{bmatrix} = \begin{bmatrix} \varepsilon_{wt} \\ \varepsilon_{rt} \\ \varepsilon_{et} \\ \varepsilon_{pmt} \\ \varepsilon_{cat} \end{bmatrix} \quad (43)$$

Quarterly observations from 1995-Q1 to 2009-Q1 are used to estimate the model with two optimal lags. All the data have been gathered from Datastream and the variables are plotted in Figure 1. Since there is evidence of a structural break around 1994Q1 in China (see for example Baak (2008)), our sample in this paper starts from 1995Q1. Furthermore there is unavailability of quarterly data for the variables involved in this paper prior to 1995Q1.

Figure 1: Plot of time series used in the VAR



4.1 Impulse response Analysis

The VAR is formulated with the following ordering: relative wage, interest rate differential, Chinese REER, relative GDP, and US current account balance. Shocks are extracted by applying a recursive identification structure with the above ordering to a vector error correction model.

$$\begin{bmatrix} w_{c,t} \\ r_{c,t} \\ e_{c,t} \\ ry_{u,t} \\ CA_{u,t} \end{bmatrix} = \begin{bmatrix} \bar{w}_{c,t} \\ \bar{r}_{c,t} \\ \bar{e}_{c,t} \\ \bar{ry}_{u,t} \\ \bar{CA}_{u,t} \end{bmatrix} + \sum_{i=0}^{\infty} \begin{bmatrix} a_{11} & a_{12} & a_{13} & a_{14} & a_{15} \\ a_{21} & a_{22} & a_{23} & a_{24} & a_{25} \\ a_{31} & a_{32} & a_{33} & a_{34} & a_{35} \\ a_{41} & a_{42} & a_{43} & a_{44} & a_{45} \\ a_{51} & a_{52} & a_{53} & a_{54} & a_{55} \end{bmatrix} \begin{bmatrix} e_{1t-i} \\ e_{2t-i} \\ e_{3t-i} \\ e_{4t-i} \\ e_{5t-i} \end{bmatrix} \quad (44)$$

Errors of the reduced form equations are related to the structural parameters as:

$$\begin{bmatrix} e_{1t} \\ e_{2t} \\ e_{3t} \\ e_{4t} \\ e_{5t} \end{bmatrix} = \begin{bmatrix} b_{11} & b_{12} & b_{13} & b_{14} & b_{15} \\ b_{21} & b_{22} & b_{23} & b_{24} & b_{25} \\ b_{31} & b_{32} & b_{33} & b_{34} & b_{35} \\ b_{41} & b_{42} & b_{43} & b_{44} & b_{45} \\ b_{51} & b_{52} & b_{53} & b_{54} & b_{55} \end{bmatrix}^{-1} \begin{bmatrix} \varepsilon_{wt} \\ \varepsilon_{rt} \\ \varepsilon_{et} \\ \varepsilon_{pmt} \\ \varepsilon_{cat} \end{bmatrix} \quad (45)$$

Introducing more simplifying assumptions:

$$\begin{bmatrix} w_{c,t} \\ r_{c,t} \\ e_{c,t} \\ pm_{u,t} \\ CA_{u,t} \end{bmatrix} = \begin{bmatrix} \bar{w}_{c,t} \\ \bar{r}_{c,t} \\ \bar{e}_{c,t} \\ \bar{pm}_{u,t} \\ \bar{CA}_{u,t} \end{bmatrix} + \sum_{i=0}^{\infty} \begin{bmatrix} \phi_{11} & \phi_{12} & \phi_{13} & \phi_{14} & \phi_{15} \\ \phi_{21} & \phi_{22} & \phi_{23} & \phi_{24} & \phi_{25} \\ \phi_{31} & \phi_{32} & \phi_{33} & \phi_{34} & \phi_{35} \\ \phi_{41} & \phi_{42} & \phi_{43} & \phi_{44} & \phi_{45} \\ \phi_{51} & \phi_{52} & \phi_{53} & \phi_{54} & \phi_{55} \end{bmatrix} \begin{bmatrix} \varepsilon_{wt} \\ \varepsilon_{rt} \\ \varepsilon_{et} \\ \varepsilon_{pmt} \\ \varepsilon_{cat} \end{bmatrix} \quad (46)$$

$$\text{where } \phi_i = \begin{bmatrix} a_{11} & a_{12} & a_{13} & a_{14} & a_{15} \\ a_{21} & a_{22} & a_{23} & a_{24} & a_{25} \\ a_{31} & a_{32} & a_{33} & a_{34} & a_{35} \\ a_{41} & a_{42} & a_{43} & a_{44} & a_{45} \\ a_{51} & a_{52} & a_{53} & a_{54} & a_{55} \end{bmatrix} \begin{bmatrix} b_{11} & b_{12} & b_{13} & b_{14} & b_{15} \\ b_{21} & b_{22} & b_{23} & b_{24} & b_{25} \\ b_{31} & b_{32} & b_{33} & b_{34} & b_{35} \\ b_{41} & b_{42} & b_{43} & b_{44} & b_{45} \\ b_{51} & b_{52} & b_{53} & b_{54} & b_{55} \end{bmatrix}^{-1}$$

$\phi_{i,j}(n)$ are impulse response coefficients for equation n. More compactly this can be represented

as:

$$x_t = \mu + \sum_{i=0}^{\infty} \phi_i(i) \epsilon_{t-i} \quad (47)$$

Given the higher US imports (more than three times the amount they export), incurring a

huge overall trade deficit, there is a growing pressure on China to raise the value of its currency, particularly from the US. This concern can be assessed via a structural VEC exercise whether the deficit is due to relative domestic demand or relative prices (real exchange rate). We therefore have used relative GDP and REER as a relative price variable. The impulse responses of REER shocks on relative GDP show that REER appreciation harms Chinese exports thereby helping US GDP increase faster than Chinese GDP, thereby leading to a decline in relative GDP between the two countries. This suggests that Chinese yuan real appreciation is required to ensure sustainability, as relative GDP shocks only lead to short-run appreciation in REER (see Figure 4). Xu (2008) reports a statistically significant long-run relationship between the RMB/dollar exchange rate and the US trade deficit with China, suggesting a need for China to adjust its exchange rate policy to help reduce the ever mounting US trade deficit.

Table 1: Estimated Matrix of Long-run Impact					
Shocks in \longrightarrow	<i>rw</i>	<i>ird</i>	<i>reer</i>	<i>ry</i>	<i>cab</i>
<i>rw</i>	0.5387*	-0.3595	-0.7420*	0.9380	-0.1203
<i>ird</i>	0.3064	1.2237*	0.3780	-0.6904	0.1899
<i>reer</i>	-0.8826*	0.1650	0.5077	-0.4475	0.2744*
<i>ry</i>	0.0505	0.0432	-0.1436*	0.2028	0.0410
<i>cab</i>	-0.0204	0.0637*	-0.0447	0.0772	0.0466*

Table 2: Estimated Matrix of Short-run effects					
Shocks in \longrightarrow	<i>rw</i>	<i>ird</i>	<i>reer</i>	<i>ry</i>	<i>cab</i>
<i>rw</i>	0.8837*	0.0000	0.0000	0.0000	0.0000
<i>ird</i>	0.0547	0.6074*	0.0000	0.0000	0.0000
<i>reer</i>	-0.4894*	0.0895	1.5268*	0.0000	0.0000
<i>ry</i>	0.0019	0.0104	-0.0133	0.0766*	0.0000
<i>cab</i>	-0.0074	0.0225*	0.0031	-0.0304*	0.0669*

Impulse responses for the empirical model, calculated with Jmulti software, are presented in Figures 2 to 6. We carried out cointegration tests to see if the variables are cointegrated. Using Johansen's cointegration tests, we found the existence of two cointegrating vectors and hence we formulated a vector error correction model (VECM) and examined the impact of each of the five

shocks on all the endogenous variables in the system. We assume relative wage to be a purely exogenous shock, as the included variables may not contemporaneously influence the labour market activity. In China, interest rates have not been an important monetary policy tool (see Mehrotra, 2007). So we consider China's interest rate differential with the US to reflect the relative price of capital and Chinese REER shocks as a standard indicator of changes in external competitiveness of China as in Marquez and Schindler (2007) who find that a 10 percent real appreciation of the renminbi lowers the share of aggregate Chinese exports by nearly one percentage point.

China's REER responds positively to shocks in all the four variables in the short-run, except the relative wage shock to which the REER responds negatively, which can happen via price adjustment by Chinese exporters (given fixed nominal exchange rate) on the back of lower profit mark-up in order to maintain its market share in the US. Under an unanticipated RMB real appreciation, the impulse responses suggest that Chinese GDP declines more than the US GDP. To prevent such outcome, it is likely that Chinese exporters could change their export prices via adjusting profit margins in order to offset the impact of real currency appreciation (see Bergin and Feenstra, 2009; Witte, 2009).

Figure 2: IRFs for relative wage shocks

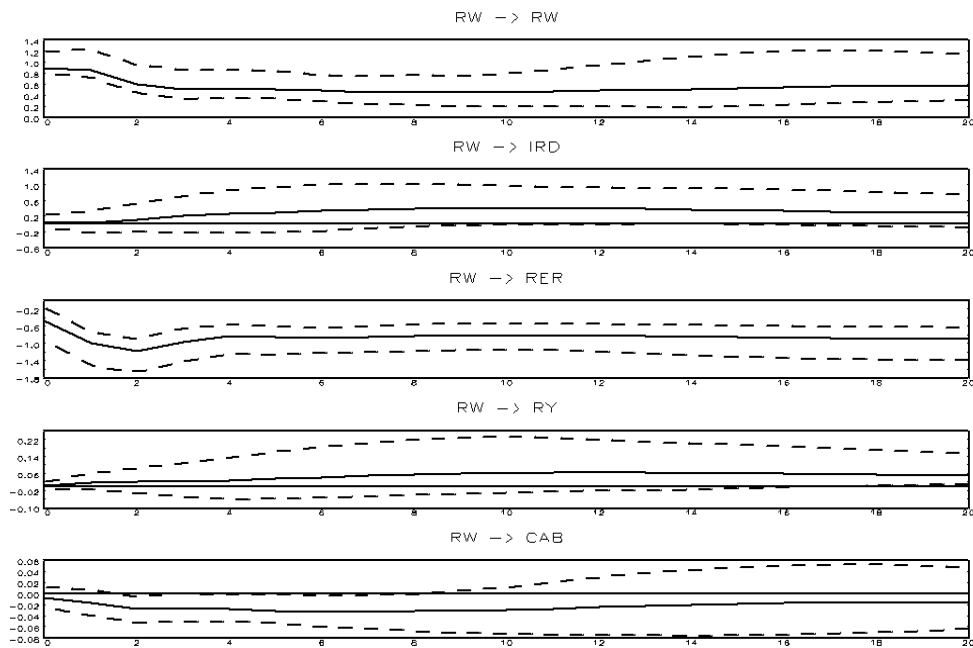


Figure 3: IRFs for shocks in interest rate differential

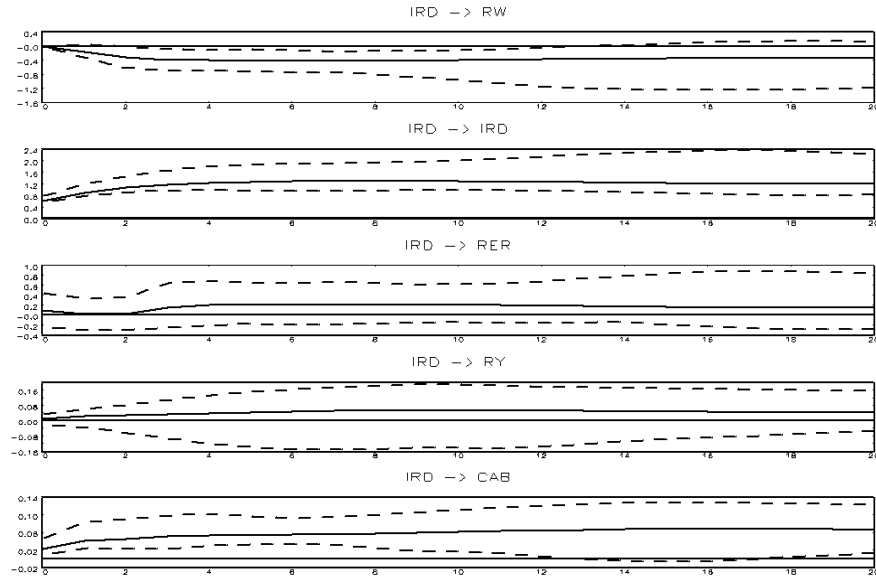
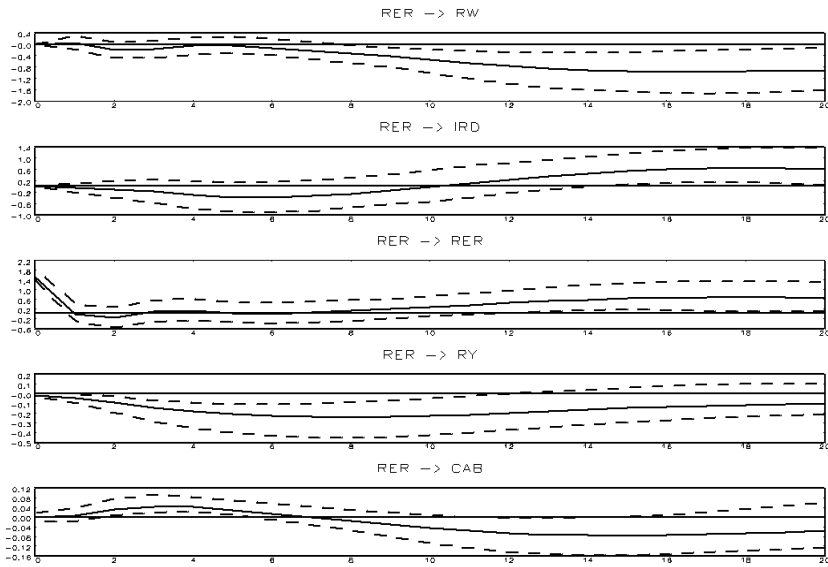


Figure 4: IRFs for Chinese REER shocks



As an important international competitiveness indicator, REER can provide a reliable gauge of price competitiveness about the relative profitability of Chinese traded goods. The results in Figure 4 imply that there could be loss in competitiveness due to RMB appreciation, leading to a

decline in Chinese GDP relative to the US. On the other hand, following a shock to relative GDP as in Figure 5, relative wage in China increases, thus lowering China's trade competitiveness and thus helping improve US current account balance. Thus lower production cost remains the key to China's trade competitiveness with the US. From Figure 6, it is clear that US current account balance can improve if it is accompanied by China's REER appreciation and an increase in China's relative wage.

Figure 5: IRFs of relative GDP shocks

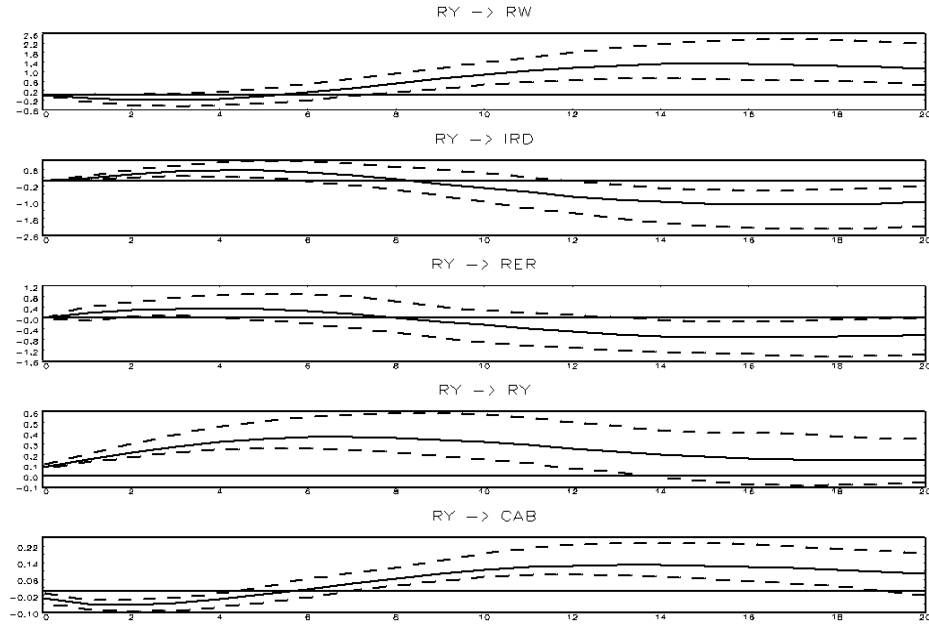
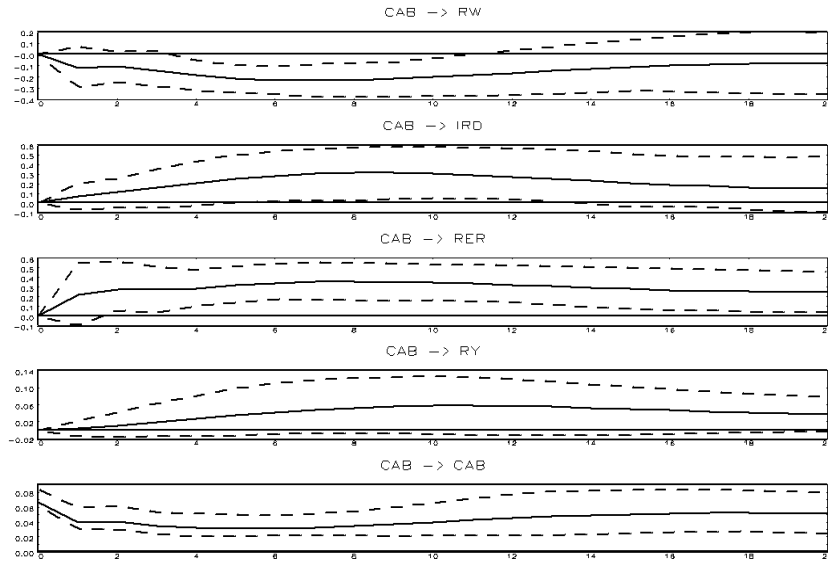


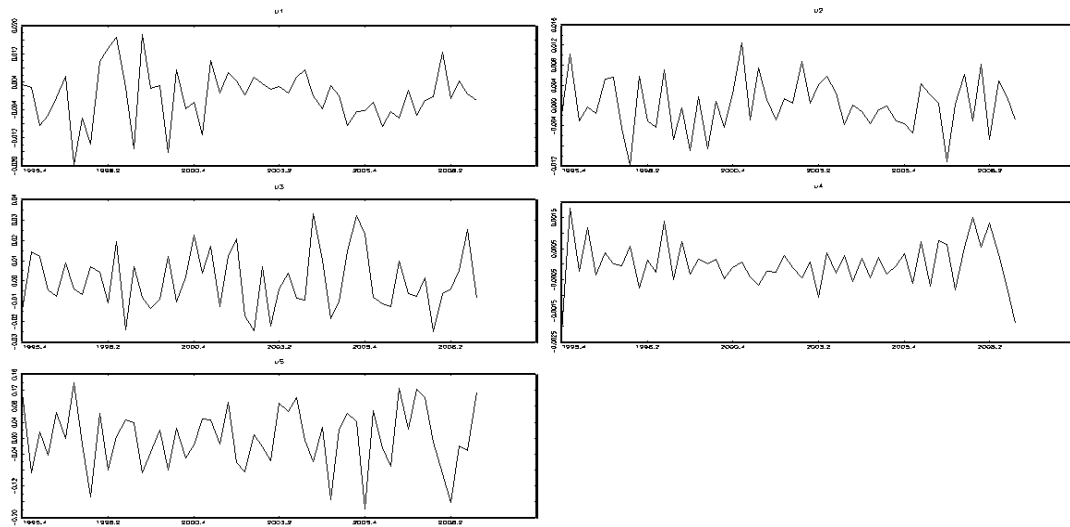
Figure 6: IRFs for shocks in US current account balance



The derived structural shocks are shown in Figure 7. Estimated structural shocks do tend to capture the turning points.

Figure 7: Derived structural shocks

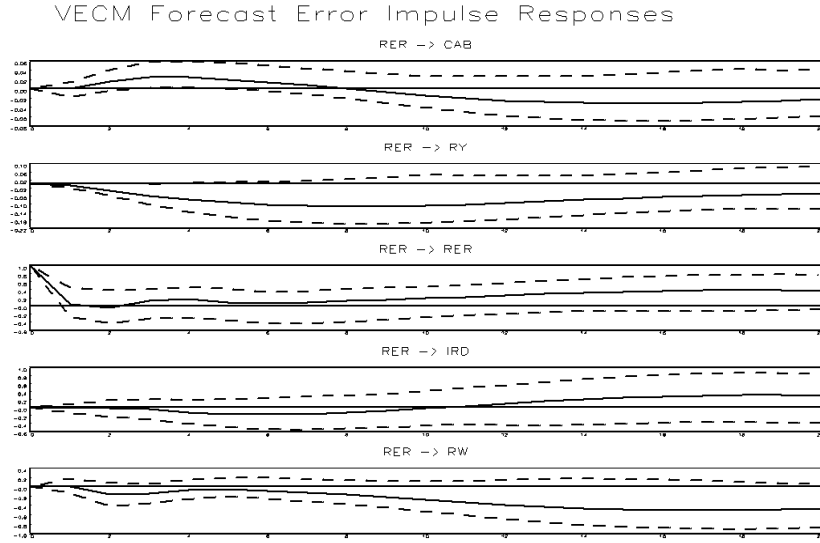
Plot of Time Series 1995.4–2009.1, T=54



For robustness check, we reordered the variables with US current account balance ordered first, followed by relative GDP, REER, interest rate differential and relative wage, in order to check the

responses of US current account balance and Chinese relative GDP, but the results remain robust. We present below in Figure 8 the responses due to shocks in REER - a key policy shock that we are interested in examining in this paper. We find that as Chinese currency appreciates, its relative GDP declines, which leads to a current account surplus in the US. It appears that relative price effects dominate the relative demand effect. When Chinese real exchange rate appreciates, it leads to an improvement in US current account balance. Thus the undervalued Chinese currency is one of the reasons why the deficit in the US current account persists. This is in line with the results in Bahmani-Oskooee and Wang (2007) at the industry level that the real yuan-dollar rate has indeed played a significant role in the trade balance between China and the US.

Figure 8: Impulse responses of REER shocks with reordering of variables



5 Variance Decomposition

Let us start from the reduced form:

$$X_t = A_0 + A_1 X_{t-1} + e_t \quad (48)$$

from successive iteration this reduces to

$$E_t X_{t+n} = (I + A_1 + A_1^2 + A_1^3 + \dots + A_1^{n-1}) A_0 + A_1^n X_t + e_t \quad (49)$$

Forecast error is given by

$$(e_{t+n} + A_1 e_{t+n-1} + A_1^2 e_{t+n-2} + \dots + A_1^{n-1} e_{t+1}) A_0 + A_1^n X_t \quad (50)$$

$$X_{t+n} - E_t X_{t+n} = \sum_{i=0}^{n-1} \phi_i(i) \epsilon_{t+n-i} \quad (51)$$

Taking only one equation

$$\begin{aligned} w_{t+n} - E_t w_{t+n} &= \phi_{11}(0) \epsilon_{wt+n} + \phi_{11}(1) \epsilon_{wt+n-1} + \dots + \phi_{11}(n-1) \epsilon_{wt+1} + \phi_{12}(0) \epsilon_{rt+n} + \phi_{12}(1) \epsilon_{rt+n-1} + \\ &\dots + \phi_{12}(n-1) \epsilon_{rt+1} \\ &+ \phi_{12}(0) \epsilon_{et+n} + \phi_{12}(1) \epsilon_{et+n-1} + \dots + \phi_{12}(n-1) \epsilon_{et+1} \\ &+ \phi_{12}(0) \epsilon_{pmt+n} + \phi_{12}(1) \epsilon_{pmt+n-1} + \dots + \phi_{12}(n-1) \epsilon_{pmt+1} \\ &+ \phi_{12}(0) \epsilon_{cat+n} + \phi_{12}(1) \epsilon_{cat+n-1} + \dots + \phi_{12}(n-1) \epsilon_{cat+1} \end{aligned}$$

Variance of n-step ahead forecast error is

$$\begin{aligned} \sigma(n)_w^2 &= \sigma_w^2 [\phi_{11}(0) + \phi_{11}(1) + \dots + \phi_{11}(n-1)] + \sigma_r^2 [\phi_{12}(0) + \phi_{12}(1) + \dots + \phi_{12}(n-1)] + \\ &\sigma_e^2 [\phi_{12}(0) + \phi_{12}(1) + \dots + \phi_{12}(n-1)] + \sigma_{pm}^2 [\phi_{12}(0) + \phi_{12}(1) + \dots + \phi_{12}(n-1)] + \\ &\sigma_{CA}^2 [\phi_{12}(0) + \phi_{12}(1) + \dots + \phi_{12}(n-1)] \end{aligned} \quad (52)$$

Variance decomposition in terms of variances of shocks ϵ_{wt} , ϵ_{rt} , ϵ_{et} , ϵ_{pmt} and ϵ_{cat} .

$$\begin{aligned} \sigma(n)_w^2 &= \frac{\sigma_w^2 [\phi_{11}(0) + \phi_{11}(1) + \dots + \phi_{11}(n-1)]}{\sigma(n)_w^2} + \frac{\sigma_r^2 [\phi_{12}(0) + \phi_{12}(1) + \dots + \phi_{12}(n-1)]}{\sigma(n)_w^2} + \\ &\frac{\sigma_e^2 [\phi_{12}(0) + \phi_{12}(1) + \dots + \phi_{12}(n-1)]}{\sigma(n)_w^2} + \frac{\sigma_{pm}^2 [\phi_{12}(0) + \phi_{12}(1) + \dots + \phi_{12}(n-1)]}{\sigma(n)_w^2} + \\ &\frac{\sigma_{CA}^2 [\phi_{12}(0) + \phi_{12}(1) + \dots + \phi_{12}(n-1)]}{\sigma(n)_w^2} \end{aligned} \quad (53)$$

Thus the variance decomposition is finding the proportion of variance explained by a variable's own shock (ϵ_{wt}) versus the variance explained by shock to the other variables ϵ_{rt} , ϵ_{et} , ϵ_{pmt} and ϵ_{cat} . The variance decomposition for the empirical model is presented in Table 7. In the variance

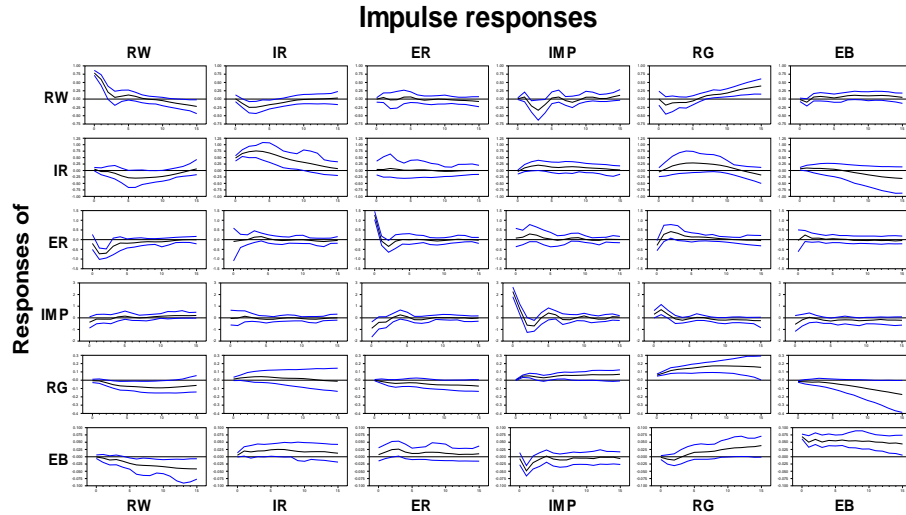
decomposition analysis, nearly 75% of the variation in US current account balance is explained by its own shocks, and relative GDP explains 29% of the variation in relative wage. As nearly 25% of the variation in US current account balance is explained by interest rate differential (11%), REER (5%), relative GDP (6%) and China's wage cost (3%), this could suggest that China's exchange rate appreciation might not solve the enlarging US current account deficits. However from the long-run and short-run parameter estimates, higher relative GDP of China does have a significant effect on lowering current account balance, and from variance decomposition results, 12% of the variation in relative GDP is on the back of China's relatively lower wage cost. Figure 2 shows that following a relative wage shock, relative GDP declines with either loss of income for the low-wage country or the rise in income for the high-wage country.

Table 3: Variance Decompositions ($k = 20$)					
Shocks in ↓	rw	ird	$reer$	ry	cab
rw	0.19	0.05	0.55	0.02	0.04
ird	0.08	0.64	0.02	0.02	0.20
$reer$	0.24	0.06	0.21	0.29	0.16
ry	0.47	0.22	0.16	0.65	0.49
cab	0.02	0.02	0.06	0.02	0.12

To further validate this result, a 6-variable VAR has been formulated by adding US import price as another variable in the VAR, following an over-identified SVAR strategy (Sims-Zha) and impose the restrictions in the matrix below:

$$\begin{bmatrix} 1 & a_{12} & 0 & 0 & a_{15} & 0 \\ 0 & 1 & a_{23} & 0 & a_{25} & 0 \\ a_{31} & a_{32} & 1 & a_{34} & a_{35} & a_{36} \\ a_{41} & 0 & a_{43} & 1 & 0 & a_{46} \\ a_{51} & a_{52} & 0 & 0 & 1 & a_{56} \\ 0 & 0 & a_{63} & a_{64} & 0 & a_{66} \end{bmatrix}$$

Figure 9: IRFs from over-identified SVAR



The technique draws a set of posterior samples from the VAR coefficients and computes impulse responses for each sample. These samples are then summarized to compute MC-based estimates of the responses using the error band methods in Sims and Zha (1999). The confidence bands are drawn by taking draws from the posterior distribution and identifying the shocks. The bands are modelled as the 16 and 84 percentile quantities for the response, which if the distribution is normal, these quantiles would correspond to a one standard deviation band as recommended by Sims and Zha (1999)². These responses further help pinpoint the effects of different shocks, consistent with the earlier results from recursive factorisation (see figure 9). The results further pinpoint how China's heavily managed exchange rate contributes to its huge trade surplus with the United States. The fixed peg currency regime of China could act as a form of "exchange rate protection", alongside China's comparative advantage coming from lower relative wage cost, which remain central to any explanation of global imbalances. With import prices as an additional variable in an over-identified SVAR, we show that higher import price shock (4th column, Figure 9) could immediately worsen US current account balance if China's fixed peg is replaced, but it will help improve the US external

²Sims and Zha (1999) found that the impulse responses from a VAR have highly asymmetrical distributions. As a result, the use of one or two standard error bands can give a misleading impression about the shape. Hence, Sims and Zha (1999) argue in favour of fractiles with 16 and 84 percentiles.

balance in the medium run.

6 Conclusion

Role of real and nominal exchange rates in flows of goods and capital are evaluated theoretically using the Ricardian comparative static and dynamic general equilibrium models. Under free trade arrangements a low income country with lower wage cost and large endowment of labour has comparative advantage in trade and accumulates foreign and domestic capital. Efficiency gains from free trade enhance economic growth and welfare of households simultaneously in both low income and advanced economies. Empirically a dynamic general equilibrium model is solved, calibrated and tested with quarterly data over the time period 1995:1 to 2009:1 on China's relative wage cost, interest rate differential, and REER (with US import price in an overidentified VAR), China's relative GDP and the US current account balance. Paper shows how the relative prices of labour, capital and the currency affect the economic activities in China and trade balance in the US. Decomposition of the variance of shocks and impulse response analyses are used to examine the size and the speed of adjustments to shocks. Dynamic simulations are compared with predictions and impulse response analyses from the VECM exercise to show how shocks to China's relative wages, REER, and relative GDP interact with the US current account balance.

Empirical findings support theoretical predictions that welfare of households in China can catch up to households in the US as the former develops dynamic comparative advantage and accumulates more capital through trade surplus to expand its production of both tradable and non-tradable products. In the long-run, China's interest rate and exchange rate shocks are positively related, while China's REER responds negatively to US import price shocks, which can happen via price adjustment by Chinese exporters (given fixed nominal exchange rate) on the back of lower wage cost in order to maintain its market share in the US. This suggests that although China's fixed peg makes the Renminbi undervalued, yet this creates dynamic comparative advantage for china and the rising US external imbalance. Higher relative prices in China will gradually erode benefits to China and can improve US trade imbalance. Aside from the fixed exchange rate policy, the real shocks in China including the low relative wages and prices, which tend to keep the country's REER at an undervalued level, are the key determinants of persistent external imbalance of the US.

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A Appendix

Detailed derivation of structural coefficients.

$$\begin{bmatrix} w_{cu,t} \\ r_{cu,t} \\ e_{c,t} \\ rv_{cu,t} \\ CA_{u,t} \end{bmatrix} = \begin{bmatrix} b_{11} & b_{12} & b_{13} & b_{14} & b_{15} \\ b_{21} & b_{22} & b_{23} & b_{24} & b_{25} \\ b_{31} & b_{32} & b_{33} & b_{34} & b_{35} \\ b_{41} & b_{42} & b_{43} & b_{44} & b_{45} \\ b_{51} & b_{52} & b_{53} & b_{54} & b_{55} \end{bmatrix}^{-1} \begin{bmatrix} b_{10} \\ b_{20} \\ b_{30} \\ b_{40} \\ b_{50} \end{bmatrix} + \begin{bmatrix} b_{11} & b_{12} & b_{13} & b_{14} & b_{15} \\ b_{21} & b_{22} & b_{23} & b_{24} & b_{25} \\ b_{31} & b_{32} & b_{33} & b_{34} & b_{35} \\ b_{41} & b_{42} & b_{43} & b_{44} & b_{45} \\ b_{51} & b_{52} & b_{53} & b_{54} & b_{55} \end{bmatrix}^{-1} \begin{bmatrix} \gamma_{11} & \gamma_{12} & \gamma_{13} & \gamma_{14} & \gamma_{15} \\ \gamma_{21} & \gamma_{22} & \gamma_{23} & \gamma_{24} & \gamma_{25} \\ \gamma_{31} & \gamma_{32} & \gamma_{33} & \gamma_{34} & \gamma_{35} \\ \gamma_{41} & \gamma_{42} & \gamma_{43} & \gamma_{44} & \gamma_{45} \\ \gamma_{51} & \gamma_{52} & \gamma_{53} & \gamma_{54} & \gamma_{55} \end{bmatrix} + \quad (A.1)$$

$$\begin{bmatrix} b_{11} & b_{12} & b_{13} & b_{14} & b_{15} \\ b_{21} & b_{22} & b_{23} & b_{24} & b_{25} \\ b_{31} & b_{32} & b_{33} & b_{34} & b_{35} \\ b_{41} & b_{42} & b_{43} & b_{44} & b_{45} \\ b_{51} & b_{52} & b_{53} & b_{54} & b_{55} \end{bmatrix}^{-1} \begin{bmatrix} \varepsilon_{wt} \\ \varepsilon_{rt} \\ \varepsilon_{et} \\ \varepsilon_{pmt} \\ \varepsilon_{cat} \end{bmatrix} \quad (A.2)$$

$$\begin{bmatrix} a_{10} \\ a_{20} \\ a_{30} \\ a_{40} \\ a_{50} \end{bmatrix} = \begin{bmatrix} b_{11} & b_{12} & b_{13} & b_{14} & b_{15} \\ b_{21} & b_{22} & b_{23} & b_{24} & b_{25} \\ b_{31} & b_{32} & b_{33} & b_{34} & b_{35} \\ b_{41} & b_{42} & b_{43} & b_{44} & b_{45} \\ b_{51} & b_{52} & b_{53} & b_{54} & b_{55} \end{bmatrix}^{-1} \begin{bmatrix} b_{10} \\ b_{20} \\ b_{30} \\ b_{40} \\ b_{50} \end{bmatrix} ; \begin{bmatrix} e_{1t} \\ e_{2t} \\ e_{3t} \\ e_{4t} \\ e_{5t} \end{bmatrix} = \begin{bmatrix} b_{11} & b_{12} & b_{13} & b_{14} & b_{15} \\ b_{21} & b_{22} & b_{23} & b_{24} & b_{25} \\ b_{31} & b_{32} & b_{33} & b_{34} & b_{35} \\ b_{41} & b_{42} & b_{43} & b_{44} & b_{45} \\ b_{51} & b_{52} & b_{53} & b_{54} & b_{55} \end{bmatrix}^{-1} \begin{bmatrix} \varepsilon_{wt} \\ \varepsilon_{rt} \\ \varepsilon_{et} \\ \varepsilon_{pmt} \\ \varepsilon_{cat} \end{bmatrix} \quad (A.3)$$

$$\begin{bmatrix} a_{11} & a_{12} & a_{13} & a_{14} & a_{15} \\ a_{21} & a_{22} & a_{23} & a_{24} & a_{25} \\ a_{31} & a_{32} & a_{33} & a_{34} & a_{35} \\ a_{41} & a_{42} & a_{43} & a_{44} & a_{45} \\ a_{51} & a_{52} & a_{53} & a_{54} & a_{55} \end{bmatrix} = \begin{bmatrix} b_{11} & b_{12} & b_{13} & b_{14} & b_{15} \\ b_{21} & b_{22} & b_{23} & b_{24} & b_{25} \\ b_{31} & b_{32} & b_{33} & b_{34} & b_{35} \\ b_{41} & b_{42} & b_{43} & b_{44} & b_{45} \\ b_{51} & b_{52} & b_{53} & b_{54} & b_{55} \end{bmatrix}^{-1} \begin{bmatrix} \gamma_{11} & \gamma_{12} & \gamma_{13} & \gamma_{14} & \gamma_{15} \\ \gamma_{21} & \gamma_{22} & \gamma_{23} & \gamma_{24} & \gamma_{25} \\ \gamma_{31} & \gamma_{32} & \gamma_{33} & \gamma_{34} & \gamma_{35} \\ \gamma_{41} & \gamma_{42} & \gamma_{43} & \gamma_{44} & \gamma_{45} \\ \gamma_{51} & \gamma_{52} & \gamma_{53} & \gamma_{54} & \gamma_{55} \end{bmatrix} \quad (A.4)$$

$$\begin{bmatrix} w_{c,t} \\ r_{c,t} \\ e_{c,t} \\ pm_{u,t} \\ CA_{u,t} \end{bmatrix} = \begin{bmatrix} \bar{w}_{c,t} \\ \bar{r}_{c,t} \\ \bar{e}_{c,t} \\ \bar{pm}_{u,t} \\ \bar{CA}_{u,t} \end{bmatrix} + \sum_{i=0}^{\infty} \begin{bmatrix} a_{11} & a_{12} & a_{13} & a_{14} & a_{15} \\ a_{21} & a_{22} & a_{23} & a_{24} & a_{25} \\ a_{31} & a_{32} & a_{33} & a_{34} & a_{35} \\ a_{41} & a_{42} & a_{43} & a_{44} & a_{45} \\ a_{51} & a_{52} & a_{53} & a_{54} & a_{55} \end{bmatrix} \begin{bmatrix} b_{11} & b_{12} & b_{13} & b_{14} & b_{15} \\ b_{21} & b_{22} & b_{23} & b_{24} & b_{25} \\ b_{31} & b_{32} & b_{33} & b_{34} & b_{35} \\ b_{41} & b_{42} & b_{43} & b_{44} & b_{45} \\ b_{51} & b_{52} & b_{53} & b_{54} & b_{55} \end{bmatrix}^{-1} \begin{bmatrix} \varepsilon_{wt} \\ \varepsilon_{rt} \\ \varepsilon_{et} \\ \varepsilon_{pmt} \\ \varepsilon_{cat} \end{bmatrix} \quad (A.5)$$